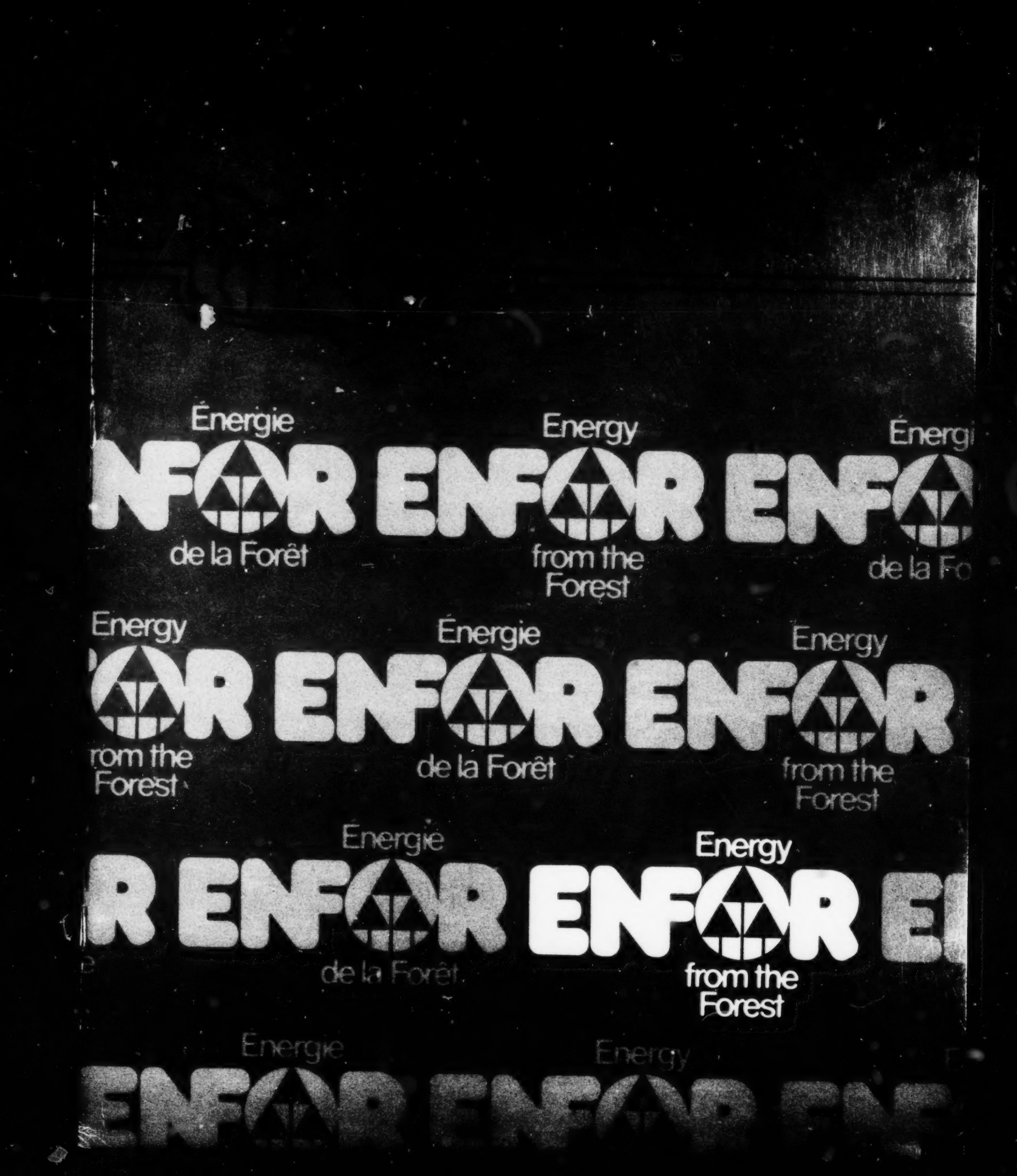
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THE ECONOMICS OF HARVESTING FUELWOOD UNDER FOUR DIFFERENT STAND CONDITIONS ON PRINCE EDWARD ISLAND

by

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ABSTRACT

Selective harvesting using modified small-scale equipment was carried out in four stand types: immature (pole-size) tolerant hardwood; mature softwood/intolerant hardwood; mature softwood/tolerant hardwood; and immature softwood. The primary end product is fuelwood. Records of labor cost, volume extracted, equipment modification and maintenance cost, and market value of extracted wood are documented for each stand type.

RESUME

Une coupe sélective a été effectuée dans quatre types de peuplements forestiers: bois dur tolérant jeune (poteau); bois tendre adulte/bois dur intolérant; bois tendre adulte/bois dur tolérant; bois tendre jeune. Ces coupes ont été faites au moyen de petits équipements modifiés. Le produit final principal est le bois de chauffage. Pour chaque peuplement forestier, les coûts de modification et d'entretien des équipements, ainsi que la valeur marchande du bois extrait sont établis.

FOREWORD

ENFOR is the bilingual acronym for the Canadian Forestry Service's ENergy from FORest (ENergie de la FORêt) program of research and development aimed at securing the knowledge and technical competence to facilitate in the medium to long term a greatly increased contribution from forest biomass to our nation's primary energy production. This program is part of a much larger federal government initiative to promote the development and use of renewable energy as a means of reducing our dependence on petroleum and other non-renewable energy sources.

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INTRODUCTION

A survey conducted by the Prince Edward Island Institute of Man and Resources (Le Clair 1980) indicated that 27.0% of the homeowners surveyed used wood for space heating and 70.6% burned wood in some fashion. In the residential sector, an estimated 232 000 m^3 (64 000 cds) of fuelwood was used in 1979/80 and 254 000 m^3 (70 000 cds.) in 1980/81. As fossil fuel prices rise the demand for fuelwood is expected to increase.

The forests of the Island have been subjected to highgrading and neglect for 300 years. An opportunity exists to rehabilitate many of the Island woodlots by cutting fuelwood to remove overstories and undesirable species, or by thinning pole-size stands. By these means, the productivity on many of the woodlots would be improved and fuelwood would be provided to an expanding market.

With this goal in mind, the study undertaken in 1981 had two major objectives:

1) to demonstrate and evaluate the economics of harvesting fuelwood under five different, but typical, stand conditions on Prince Edward Island; and

2) to improve the productivity and value of Island woodlots.

Five different stand types were identified which would lend themselves to a fuelwood harvest and at the same time increase the productivity of the remaining stand. These were

1. immature (pole-size) tolerant hardwoods, (ITH)

2. immature (pole-size) intolerant hardwoods, (IIH)

3. immature softwoods, (IS)

4. mature softwood/intolerant hardwoods, (MS/IH)

5. mature softwood/tolerant hardwoods, (MS/TH)

STUDY AREA DESCRIPTION

In the original proposal, about 2-ha blocks of five stand types were to be studied: immature (pole-size) tolerant hardwood (ITH), Brookvale, Queens Co.; mature softwood/intolerant hardwood (MS/IH), Brudenell, Kings Co.; mature softwood/tolerant hardwood (MS/TH), Valleyfield, Kings Co.; immature softwood (IS), Valleyfield; and immature (pole-size) intolerant hardwood (IIH), Brudenell.

Average stand height and age (based on 10 dominant and codominant trees) of the ITH stand were 9.5 m and 25 years, respectively. The major species were sugar maple (Acer saccharum Marsh.), yellow birch (Betula alleghaniensis Britton), red maple (Acer rubrum L.), and white birch (Betula papyrifera Marsh.) (Fig. 1.)

The MS/IH stand was about 12.0 m in height and 50 years old. The major species were red maple, white spruce (Picea glauca (Moench) Voss), white birch, and balsam fir (Abies balsamea (L.) Mill) (Fig. 2).

The MS/TH stand had an average height of 19.0 m and age of 65 years. The major species were balsam fir, red maple, white birch, sugar maple and yellow birch (Fig. 3).

The IS stand was pure white spruce of old field origin, 13.0 m high and 40 years old (Fig. 4).

Detailed information on stem count, merchantable volume, and species composition is recorded in Table 1. Further information on basal area and total volume is shown in Appendix I.

METHODS AND MATERIALS

The sequence of cutting operations was consistent in each stand type. Extraction trails, 2.4 m wide, were cut at 15.2 m intervals, by the foreman and two cutters. When cutting had progressed sufficiently, the foreman began extraction. When all trails were cut, thinning began, one cutter per strip. The foreman cut intermittantly.

Softwoods were sometimes removed to improve the quality of the stand. In such cases the softwood was cut to produce the product with the highest return. Since softwood pulp and logs were of higher value than softwood fuelwood (Table 2), 2.4 m (8 ft) pulp and 2.4 - 3.0 m logs were cut, where possible. All stands were thinned using chain saws. The methods of extraction varied within and between stands.

In the ITH stand, the overstory was thinned and clumps were reduced to 2-3 stems. Yellow birch and sugar maple were favored. A farm tractor (135 Massey Ferguson) and manual loading/unloading 2.4-m trailer were used for extraction. Winching was attempted but was soon abandoned because the small stems continually slipped through the chokers.

In the MS/IH stand, a crown release was carried out to free the hardwoods and emerging softwoods. Overmature balsam fir was removed. Two methods of extraction were used under the same conditions: the tractor/manual trailer and the tractor/winch (Norse 2500 Kombi) (2.4 m length skidded butt first).

Figure 1. Immature tolerant hardwood stand before fuelwood cut (A); after cut (B).

Figure 2. Mature softwood/intolerant hardwood stand before fuelwood cut (A); after cut (B).

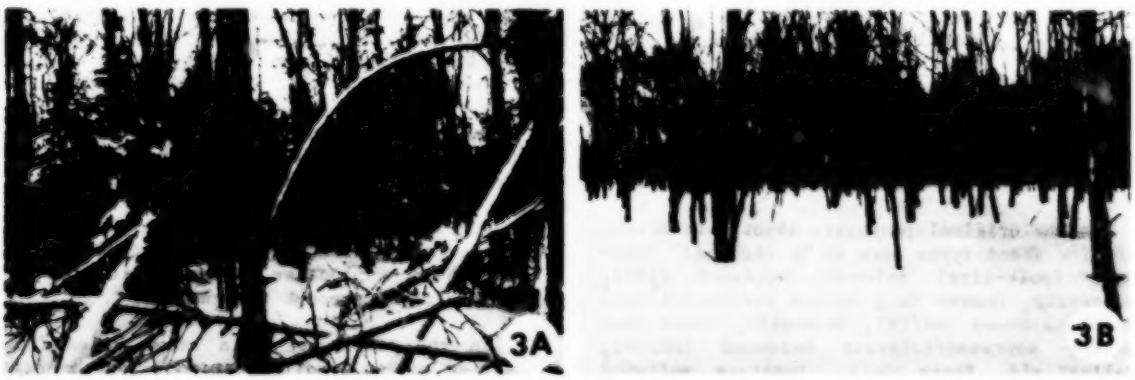

Figure 3. Mature softwood/tolerant hardwood stand before fuelwood cut (A); after cut (B).

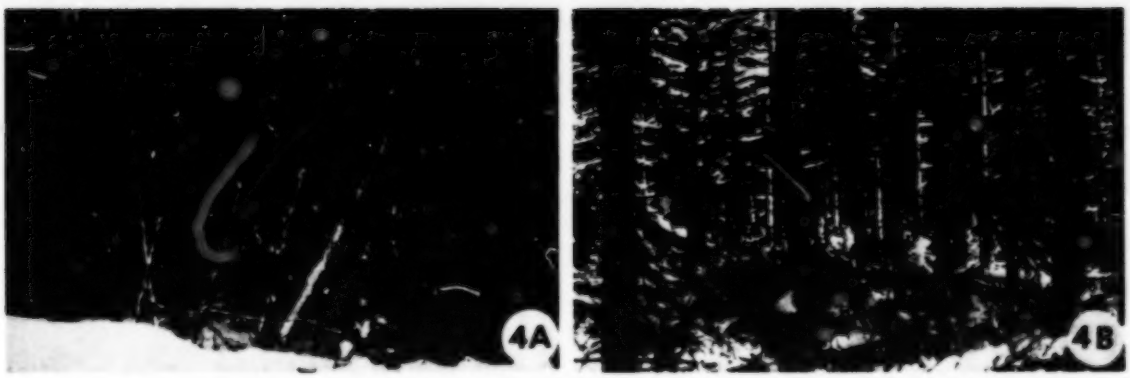

Figure 4. Immature softwood stand before fuelwood cut (A); after cut (B).

Table 1. Stem count (>1cm dbh ob), merchantable volume (above 9cm dbhob), and species composition (based on number of stems) of four stand types on Prince Edward Island, before and after thinning

Stand type species	Stems/ha		Merchantable volume (m /ha)		Species composition (%)	
	Before	After	Before	After	Before	After
Mature softwood/ tolerant hardwood (MS/TH)						
Balsam Fir	647	--	38.0	--	39	--
Red Maple	350	593[a]	50.4	35.7	21	53
White Birch	326	109	34.9	15.5	19	10
Sugar Maple	145	301[a]	20.0	22.4	9	27
Yellow Birch	104	118[a]	12.1	13.9[a]	6	11
White Spruce	88	--	11.6	--	5	--
Beech	10	--	3.7	--	1	--
Total	1670	1122	170.7	87.6		
Immature tolerant hardwood (ITH)						
Red Maple	938	82	1.5	1.4	14	2
Sugar Maple	2796	1247	8.3	4.0	42	30
White Birch	814	1306[a]	10.1	7.8	12	32
Yellow Birch	1644	1249	5.6	5.9	25	31
Balsam Fir	444	62	7.9	5.1	7	2
Beech	--	147	--	0	--	0
Total	6636	4093	33.3	24.2		
Mature softwood/ intolerant hardwood (MS/IH)						
White Spruce	2080	244	34.2	18.0	25	10
Red Maple	2944	1042	20.3	15.6	36	42
White Birch	2008	721	29.9	22.9	24	29
Balsam Fir	707	324	25.4	16.9	9	13
Black Spruce	482	111	4.5	6.5[a]	6	4
Beech	--	28	--	1.9	--	1
Total	8220	2470	114.4	81.8		
Immature softwood (IS)						
White Spruce	9712	1929	188.4	107..	100	100

[a]Location of plots differed before and after thinning.

Table 2. Assumed prices for wood products in 1982 on Prince Edward Island[a]

Product	Price $/m^3$
Hardwood fuelwood	12.42
Softwood fuelwood	8.28
2.4-m softwood pulp	8.83
2.4-m softwood logs	12.42
3.0-m softwood logs	14.35

[a]Wood value based on 1982 roadside sales prices.

In the MS/TH site, most of the softwood was removed and the remaining hardwoods were crown released by thinning clumps and removing single stems. Again, yellow birch and sugar maple were favored. All wood was removed by the tractor/modified (self-loading and unloading winch powered) trailer (Figs. 5, 6, and 7).

In the IS stand, about 40% of the volume was removed, leaving the larger diameter stems. Pulpwood was cut, and stems with diameters too small for pulpwood were cut for fuelwood, the top diameter limit being 6.4 cm. The wood from the extraction trails was removed by tractor/modified trailer. Snow accumulation, while great, was not excessive in the softwood stand, and thinning was able to continue until the end of the study. The wood from the thinning operation was extracted by snowmobile and a 152.5-cm sled (Fig. 8). The modifications and their costs, which were necessary to outfit equipment for woods work, are shown in Appendix II.

However, weather and snow depth allowed the completion of harvesting of only the ITH and MS/IH stands, and the partial harvesting of the MS/TH and IS stands. Operations on the IIH stand were not initiated.

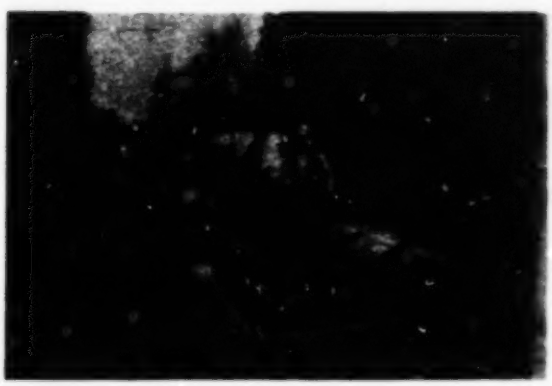

Figure 5. Self-tipping trailer.

Figure 6. Self-tipping trailer unloading.

RESULTS AND DISCUSSION

Fuelwood was removed from all stand types. Hardwood fuelwood was the only product extracted from the ITH stand. In the MS/IT stand, hardwood fuelwood and softwood pulpwood and logs were removed. In the MS/TH stand, hardwood fuelwood and softwood logs were extracted. Softwood fuelwood and pulpwood were products of the IS stand.

Comparing the volume (stacked cubic metres) of fuelwood removed by the harvesting operation on a per hectare basis (Table 3), the IS stand showed the greatest volume. The MS/TH stand produced the greatest volume of hardwood fuelwood. Though lower than the softwood fuelwood volume on a per hectare basis, the hardwood fuelwood in the MS/TH stand produced a greater net return ($558.00 - hardwood vs $543.00 - softwood). The same order (IS, MS/TH, MS/IH and ITH) of decreasing extracted volume applies to all products removed (fuelwood, pulpwood, and sawlogs).

Extraction methods within and between stands can also be compared. In two areas, extraction was varied within the stand, and thus the better method can be suggested for each of those stands. In the MS/IH stand, where the terrain was a gentle pit and mound (typical under stands of this type on Prince Edward Island) the tractor/manual trailer had a slightly better extraction rate than the tractor/winch (Table 3). In the IS stand, the snowmobile/sled had an advantage over the tractor/modified trailer in the snowcover. The terrain in this stand was flat because it was originally an old field. However, the tractor/modified trailer exhibited a better extraction rate on gentle pit and mound terrain, under snow conditions. The extraction rate of the tractor/modified trailer in the MS/TH stand equalled that of the snowmobile/sled in the IS stand, again suggesting the capability of the former under favorable ground conditions.

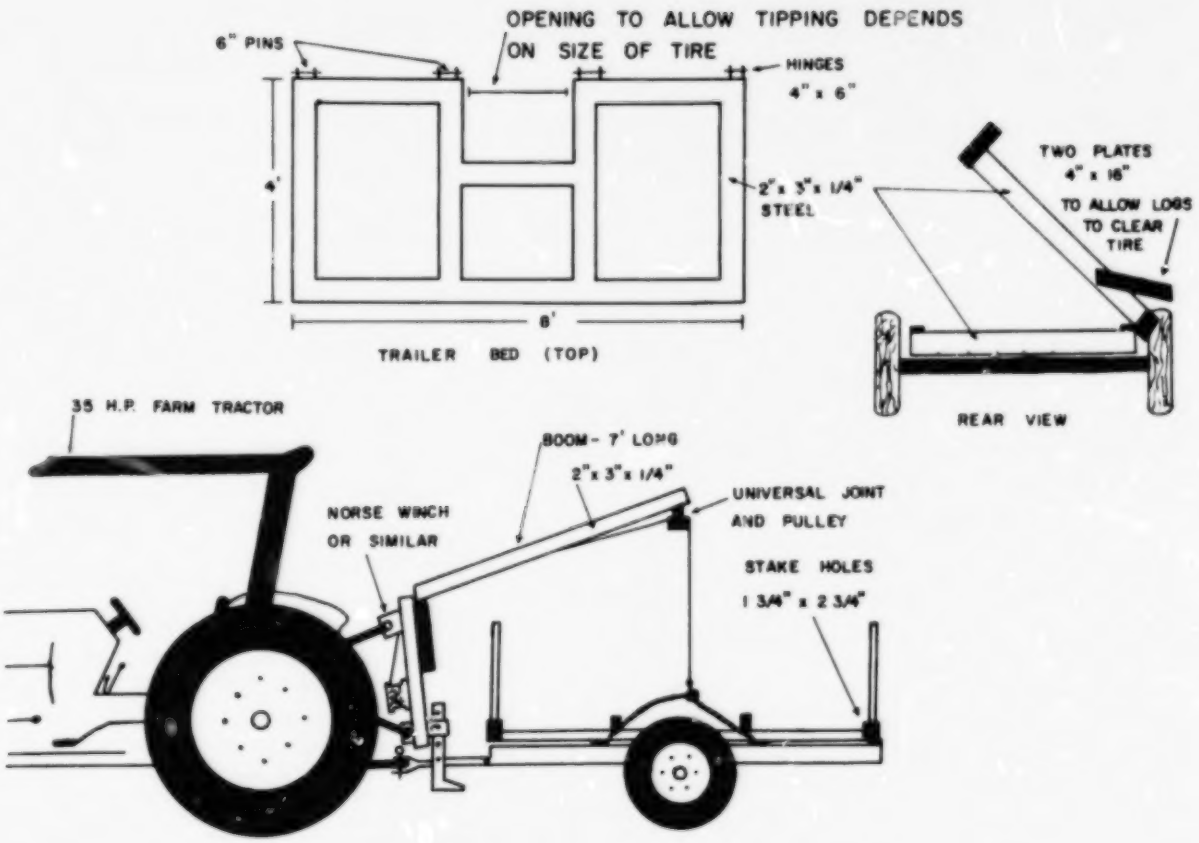

Figure 7. Self-loading/unloading (winch powered) trailer.

Figure 8. Snowmobile sled modified to carry pulpwood.

A comparison of the manual and modified trailers on similar terrain (MS/IH and MS/TH respectively) reveals a slightly better rate for the latter, possibly due to the mechanization of the loading and unloading operations.

The poor extraction rate in the ITH stand can probably be accounted for by the moderate to severe pit and mound terrain.

Extraction rates in this study compared favorably with those documented in the literature. Stevens and Smith (1980) used small-wheeled tractors and winches to skid tree length in a fuelwood thinning. Productivity was determined to be 0.5 man-hours/m^3. A study of the Farmi JL 30 winch on a 38-

Table 3. Productivity of various operations of fuelwood harvesting determined in four stand types on Prince Edward Island, 1981/82

Operation	Immature tolerant hardwood	Mature softwood/ intolerant hardwood		Mature softwood/ tolerant hardwood	Immature softwood	
Extraction method	Tractor/manual trailer	Tractor/ manual trailer	Tractor/ winch	Tractor/ modified trailer	Tractor/ modified trailer	Snow-mobile/ sled
Avg distance (m)	189	336	128	196	168	141
Man-hours/m³	0.7	0.3	0.4	0.2	0.4	0.2
Harvesting - Man-hours/ha						
Cutting trails	15.4	15.5		8.4	58.2	
Thinning	48.1	80.8		143.8	306.8	
Total operation[a]	82.8	116.2	136.9	184.5	471.1[b]	
Fiber Production - m³/ha						
Fuelwood only	22.8	63.0		108.7	162.1	
All products	22.8	66.1		124.8	249.9	

[a]Includes cutting extraction trails, thinning, extraction and shop maintenance.
[b]Unable to derive a figure for each extraction method.

horsepower tractor, wood skidded tree-length, resulted in extraction productivity of 0.3 man-hours/m³ in a hardwood stand and 0.4 man-hours/m³ in a mixedwood stand (Folkema 1977). Other studies in softwood logging using mechanical and hydraulic winches on farm tractors gave results in a range of 0.2 to 0.08 man-hours/m³ (MacArthur 1974). Renaud (1981)[1] documented productivity of 0.5 man-hours/m³ for both a portable winch and light tractor equipped with tracks and tracked trailer, in commercial softwood thinnings.

The feasibility of any operation can only be determined when a monetary value is placed on labor expended and products. In this study, variables were assigned costs and prices. Hourly rates for labor and equipment were determined for the purpose of this study (Table 4). Calculations for equipment costs were also made. Using the rates and prices for wood products from Table 2, cost of the total operation, gross return, and net return on a per hectare basis were determined for each stand type (Table 5).

Table 4. Hourly equipment and labor costs assumed for a fuelwood harvesting study on Prince Edward Island in 1981/82

Item	Cost/h ($)
Labor	6.25
Chain saws	1.40
35-hp farm tractor	5.00
Winch	1.20
Manual trailer	0.10
Modified trailer	0.30
Snowmobile	3.60
Sled	Negligible

The costs determined for the thinning operations should be studied closely with the production figures (Table 3). The ITH stand has the lowest cost per hectare because of the low volume removed. This resulted in a reduced time for the thinning operations but the rate is still too high for a viable operation. Again because of the low volume removed, gross return was low and net return was negative. The use of brush saws instead of chain saws may have improved the thinning rate.

The second lowest cost of operations was in the MS/IH stand. Here too, the thinning

[1]Renaud, D.F. 1981. An evaluation of five harvesting systems used in commerical thinnings. Unpubl. undergrad. thesis, Lakehead University. 32 p.

Table 5. Cost and returns from fuelwood harvesting in four stand stand types on Prince Edward Island, 1981/82

Stand	Cost incurred	Gross return ($/ha)	Net return
Immature tolerant hardwood	656.00	282.00	- 374.00
Mature softwood/ intolerant hardwood	1024.00	810.00	- 213.00
Mature softwood/ tolerant hardwood	1508.00	1566.00	+58.00
Immature softwood	3560.00	2118.00	-1442.00

operation kept the cost down. This rate (80.8 man-hours/ha) was better than that recorded in similar stands on Prince Edward Island - 183 man-hours/ha and 156 man-hours/ha (Peters 1982)[2]. A large quantity of wood was removed from this site considering the amount of time spent thinning, but not enough to cover the cost of the total operation. Thus, a negative return resulted. With a reduced amount of time for thinning and the better extraction rates of the tractor/manual trailer (0.3 man-hours/m^3) or the tractor/modified trailer (0.2 man-hours/m^3), this might have been a viable operation, or at least a break-even venture.

Improvement of the MS/TH stand resulted in the only profitable thinning operation. There were several contributing factors: the merchantable volume before thinning was high and a 50% volume removal resulted in a high gross return; the original density of the stand was low so time to cut extraction trails was almost halved; the time required to thin the stand was also short, and the extraction rate was excellent. Improved thinning rates could have increased the profit even more.

Fuelwood harvesting in the IS stand resulted in the poorest net return for all stand types treated. This can be attributed to the high stem count that caused the rates for cutting of extraction trails and thinning to increase substantially. Another contributing factor was snow depth. Cutting for pulpwood and logs in a slightly less dense old field white spruce stand during the summer resulted in thinning rates of 121.1 and 140.8 man-hours/ha (Peters 1982)[2] respectively. Thus, better thinning rates under more favorable conditions may have decreased the total cost of the operation, possibly to a break-even point.

CONCLUSIONS AND RECOMMENDATIONS

In the four stand types studied, the mature softwood/tolerant hardwood thinning proved to be the only profitable operation under the conditions encountered. With improved thinning rates and better operating conditions, three of the four operations might at least, break even, or even be profitable. This in addition to the future benefit of an improved stand, would be an attractive incentive for stand improvement.

The tractor/modified trailer and the snowmobile/sled exhibited the best extraction rates, and under favorable conditions, the tractor/manual trailer showed an acceptable extraction rate.

This study has attempted to provide limited information to commercial fuelwood producers and woodlot owners interested in harvesting fuelwood. The realm of this project is only a part of the enormous area of research on renewable energy from forest biomass. Many facets are yet to be examined. The conclusions of this study lend themselves to further study of the same nature and to studies in related areas, for example, the production of other forms of wood fuel, such as wood chips from small woodlots.

ACKNOWLEDGEMENTS

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APPENDIX I

Basal area and total volume of four different stand types on Prince Edward Island

Stand type / Species	Basal area (m^2/ha) Before	Basal area (m^2/ha) After	Total volume (m^3/ha) Before	Total volume (m^3/ha) After
Mature softwood/ tolerant hardwood	34.1	18.6	193.2	100.8
Balsam fir	9.6	-	45.0	-
Red maple	8.9	8.2	56.1	41.3
White birch	6.9	3.1	39.0	17.1
Sugar maple	3.4	4.6[a]	22.3	26.7[a]
Yellow birch	2.4	2.6[a]	13.6	15.8[a]
White spruce	2.1	-	13.3	-
Beech	0.7	-	3.9	-
Immature tolerant hardwood	20.6	16.5	42.7	33.6
Red maple	1.9	0.6	1.8	1.9
Sugar maple	7.6	4.3	11.4	5.5
White birch	4.7	5.6[a]	13.7	12.1[a]
Yellow birch	4.7	4.5	7.3	8.1[a]
Balsam fir	1.6	1.0	8.5	6.0
Beech	-	0.4	-	0
Mature softwood/ intolerant hardwood	44.4	23.1	145.7	101.0
White spruce	12.4	3.7	42.2	21.5
Red maple	12.2	6.4	28.3	21.4
White birch	10.3	6.8	38.2	27.6
Balsam fir	7.0	4.1	31.5	20.3
Black spruce	2.5	1.7	5.7	7.9[a]
Beech	-	0.4	-	2.3
Immature softwood	66.7	27.9	233.1	130.5
White spruce	66.7	27.9	233.1	130.5

[a]Location of plots differed before and after thinning.

APPENDIX II

Modifications and costs of modifications of equipment

Modifications	Cost
Tractor	
Roll bar	$357.50
Chains	300.00
Steel and expanded metal - for radiator protection, back of roll bar, stem valves, and tool box rack	106.51
	$764.01
Trailer	
Steel tubing - for bed and boom	$306.58
Shaft	32.56
Chains - to steady boom and lift bed	31.55
Clamps, links, clevices, studs, washers	25.56
	$396.25
Snowmobile	
Steel plate - for back of snowmobile	$ 30.00
Lower gear ratio	125.00
	$155.00